VENUS SAMPLE RETURN OPTIONS

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In cooperation with NASA's Solar System Exploration Subcommittee (SSES) the Jet Propulsion Laboratory (JPL) is conducting a series of studies to assess the feasibility of planetary science missions proposed for launch in the 2006-2010 time frame and to prioritize technology development steps that will enable these missions. Until recently the return of sample material from the surface of Venus was widely considered to be beyond the technological and financial capabilities of the NASA Space Science Program for this time frame, but technological and programmatic advances may now have brought such a mission within our reach. This presentation will describe the results of an ongoing study to investigate the feasibility of various options proposed for a Venus Sample Return (VSR) Mission and to develop a mission concept to be considered in NASA's strategic planning. Included will be discussions of the science objectives, the major system and subsystem trade-offs, and a preliminary mission concept.

The principal science objective of the mission would be to return samples of surface and atmospheric material to Earth for detailed chemical analysis. Our knowledge of the surface chemistry of Venus is based on a limited number of elemental analyses done by the Venera landers. We have no data on surface mineralogy, which would provide significant constraints on models of evolution of the venusian crust. We have no idea of the volatile content of the rocks; how much water is contained in Venus surface samples would help constrain models of the evolution of the Venus atmosphere and interior. Even more importantly, the venusian impact crater population is distributed randomly, preventing us from determining the ages of surface units. One type of terrain on Venus, called tessera, has been compared to the ancient cratons of Earth, but its age and composition are unknown. Understanding the age and origin of the tessera is critical to differentiating between models of the evolution of the interior of Venus, so acquiring tessera samples would probably be the highest priority for the mission.

Returning a sample of the venusian atmosphere is also of extremely high scientific priority. More detailed analyses of the atmospheric chemistry, in particular the isotopic composition, utilizing the more sophisticated laboratory equipment available on Earth would enable us to better address the nature and evolution of the venusian atmospheric greenhouse. In addition, we have little knowledge of the chemical composition of the lower atmosphere of Venus. Detailed chemical analyses are difficult to perform at high temperature. The lower atmosphere is a key link between surface and interior processes; understanding the detailed composition of the lower atmosphere can help constrain the current reactions taking place between the surface and atmosphere, as well as address fundamental outstanding questions on the volcanic history of the planet.

Venus sample return missions have been proposed in the past, but a number of current developments have provided or will provide substantial additions to the technology base needed to assure success of such a proposal. In addition to the heritage provided by the Mariner, Venera and Vega missions of the 70s and 80s, a VSR mission in the next decade will benefit from the understanding of the planet and particularly of aerobraking possibilities provided by Magellan, from the development of many elements of a planetary sample return mission by the NASA/CNES Mars Sample Return (MSR) Program and by the New Millennium DS4 Project (including ascent vehicle, orbiter, rendezvous and docking system and Earth entry vehicle), from extensive Venus balloon technology development work at JPL and elsewhere, and from the general trend toward small, lighter spacecraft systems.

The presentation will describe the results of trade studies currently under way for the following elements of the VSR mission:

- Launch vehicle/spacecraft propulsion: Solar electric propulsion may provide increased performance but may not be cost effective compared with a step up in launch vehicle size coupled with conventional propulsion;

- Entry/descent/landing: How to make best use of the Magellan experience for aerobraking and possibly for aerocapture of an orbiter element;

- Surface operations: Sample selectivity and documentation of context traded off against cost and complexity of operating for any significant length of time on the surface (700 K, 100 bar);

- Ascent/rendezvous/docking/sample transfer: Various combinations of balloons, blimps, airplanes, and rockets have been proposed over the years and these are being reevaluated taking into account current and projected technology development in each area. Tolerance of the surface environment by the landed element of the ascent system is a key factor. The atmospheric elements involve a plethora of options which are discussed in detail in a separate presentation. The study is attempting to maximize reuse of systems being developed by DS4 and MSR in order to minimize cost.

- Earth return/Earth entry: Reuse of Mars and/or Stardust systems will probably be cost effective here.

A preliminary mission profile (at the time of abstract submission) includes:

- A single launch of all elements using conventional propulsion;

- Orbiter aerobrakes into Venus orbit;

- Lander descent similar to Pioneer Venus (blunt heat shield, parachute), landing site selected using Magellan data, landed element includes ascent balloon and ascent rocket;

- Quick grab samples using two or more acquisition devices (no selectivity);

- Balloon ascent to 50-60 km;
- Rocket ascent to orbit;
- Rendezvous, sample transfer, Earth return similar to Mars 2005 mission.

The presentation will update this profile and describe the trade study findings.